Topological phase and Devil's staircase transition of the electronic structures in cerium monopnictides

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In condensed matter, the formation of spatially modulated structures such as magnetic structures, charge-density waves, and orbital ordering occasionally occurs. Since quasiparticles are exposed to the newly produced boundary, these modes can be distinguished by a certain periodicity and symmetry in the electronic structure, which are related to underlying electronic instabilities. The electronic system is affected by the frustration caused by multiple competing orders, and thus displays highly complicated features. Among them, the "devil's staircase" discovered in the magnetically ordered CeSb more than 40 years ago is one of the most complicated phenomena. We use bulk-sensitive angle-resolved photoemission spectroscopy and demonstrate the devil's staircase transition in the electronic structure [1]. The band dispersion at each transition is significantly reconstructed by different magnetic configurations. In addition, the well-defined band picture is found to collapse near the Fermi energy under long-periodic modulation in a certain phase, whereas it recovers during the transition into the ground state at the lowest temperature. We further find a novel electron-boson coupling that notably renormalizes the Sb 5p band and induces a pronounced kink structure at very low energy (7 meV) attributed to excitations of the 4f orbitals with quadrupole crystal electric field [2]. It generates a novel sort of quasiparticle known as the "multipole polaron", consisting of a mobile electron dressed by a cloud of the quadrupole crystal-electric-field polarization. The electron-boson coupling is extremely strong and exhibits anomalous step-like enhancement during the devil's staircase transition with temperature. In my presentation, we also investigate the bulk electrical structures of the Ce monopnictide series (CeP, CeAs, CeSb, and CeBi), and construct the topological phase diagram. In particular, we demonstrate the topological phase transition from a trivial to a nontrivial regime in moving from CeP to CeBi, which occurs due to the band inversion with an increase in the spin-orbit coupling [3]. Our thorough observations uncover the detailed electronic properties of the fascinating series materials.

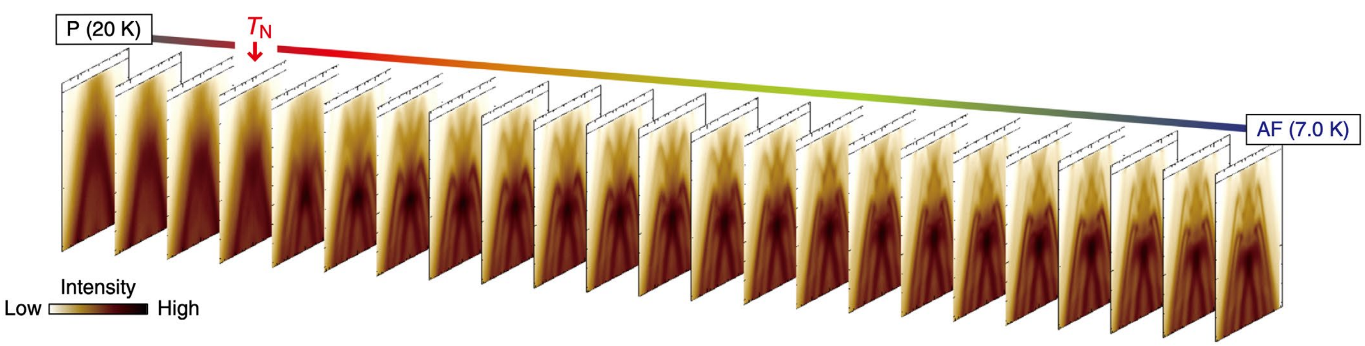

Fig.1: Devil's starecase transition reveald in the band dispersion measured by ARPES.

References

[1] K. Kuroda *et al., Nature Communications* **11**, (2020).
[2] Y. Arai *et al., Nature materials* **21**, 410 (2022).
[3] K. Kuroda *et al., Physical Review Letters* **120**, 086402 (2018)